

Rectal 3D MRI modelling for benign and malignant disease

Editor

High resolution MRI is used to plan surgery for both benign pelvic floor dysfunction and rectal cancer. Whilst MRI is useful, interpretation of sequenced two-dimensional images can be challenging to comprehend. Three-dimensional (3D) radiologically derived models may facilitate better understanding of anatomy and surgical planes. This letter describes the application of 3D modelling technology for rectal surgery. 3D virtual models were constructed in 30 patients having MRI scans to stage rectal cancer or having MRI proctogram. For rectal cancer patients, MRI T2-weighted images of the rectum and pelvis with 3 mm slices were

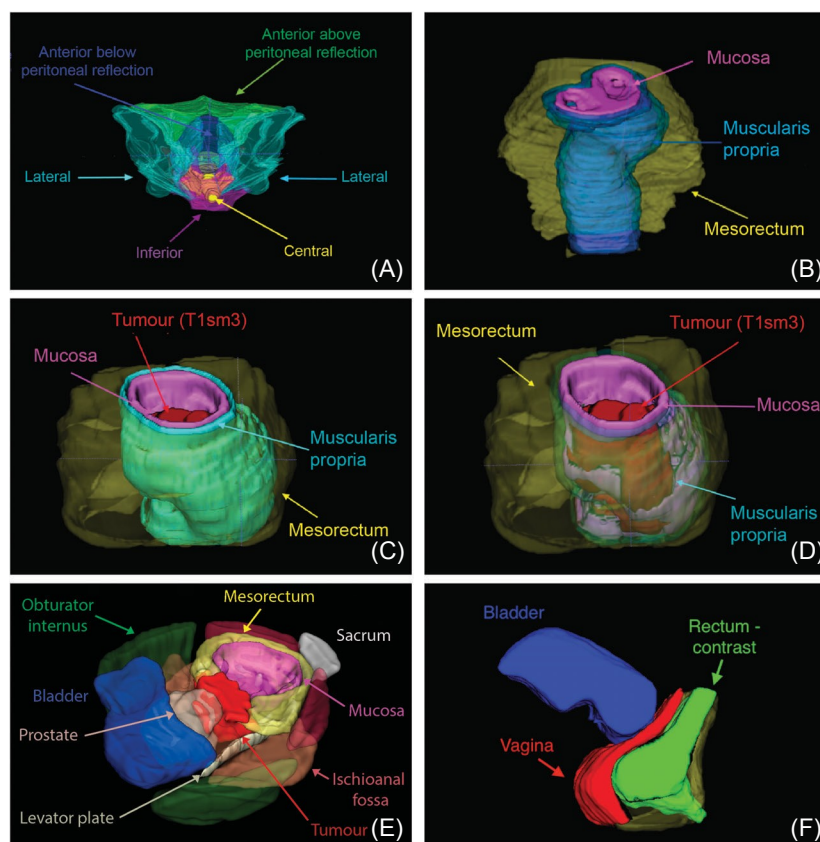
obtained (rectal cancer protocol). No additional patient time or preparation was required. DICOM images were imported into ITK-SNAP or 3D Slicer, open source programmes, previously validated for constructing 3D anatomical models from medical imaging^{1,2}. Depending on the model constructed, rectum, pelvic organs or pelvic compartments, were delineated and triangular meshes obtained. Virtual 3D models displaying either the whole pelvis or the organs of interest were constructed. Further smoothing and post-processing were performed in MeshLab. 3D animations were then created to improve the comprehension and the ease of use.

Three types of pelvic 3D virtual models have been constructed. 1. Models depicting seven anatomic pelvic sur-

gical compartments, including normal anatomy (Fig. 1A) and rectal cancer³ 2. Models to evaluate rectal cancer within the central pelvic compartment, with the submucosa, muscularis propria and mesorectum delineated individually on the 3D reconstruction (Fig. 1B). 3D modelling has been used to evaluate different rectal cancer T stages, as depicted in figures 1C, 1D and 1E. 3. Models to evaluate pelvic functional disorders, such as a patient with a rectocele shown in Fig. 1F.

Three dimensional (3D) models allow better comprehension and easier visualisation of individual patient anatomy and thus can form an important part of patient-tailored surgery. 3D imaging technology and visualisation have been successfully used in maxillofacial, orthopaedic, cardiac and hepatobiliary

Fig. 1 3D virtual models of pelvis and rectum. (A) Pelvic surgical compartments, normal anatomy. (B) Normal rectum. (C) Rectal cancer T1 sm3, muscularis propria intact. (D) Rectal cancer T1 sm3, mucosal defect visible. (E) Rectal cancer T4 invading prostate. (F) Rectocele



surgery. However, they are not widely used in colorectal surgery^{4,5}.

This study demonstrates the potential of this technology within colorectal surgery. The ease of anatomical interpretation should facilitate multidisciplinary discussion and patient management. The transparency of each layer can be adjusted to allow inspection of individual anatomical planes. Models of T1 rectal cancer can help with feasibility assessment and planning of localised excision. Where TME surgery is planned, understanding of individual patient anatomic variation and relationships facilitates surgery. The concept of pelvic compartments is relevant to advanced rectal cancer where multivisceral resection may be indicated. Another potential use of this technology is to digitally print into physical models of the images attained.

The main limitation for clinical application of this technique are the time and workload requirements. At present, models are constructed through manual segmentation of each slide of the MRI scan. The time required to construct

one model depends on complexity, but can take a few hours. This limitation can be addressed through the introduction of automated segmentation techniques using machine learning. Such automated tools can reduce the time required to construct one model from hours to minutes.

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